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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/894,230	06/27/2001	Francis Ko	LAM2P257	4834

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EXAMINER

RUGGLES, JOHN S

ART UNIT	PAPER NUMBER
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1756

DATE MAILED: 02/03/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/894,230

Applicant(s)

KO ET AL.

Examiner

John Ruggles

Art Unit

1756

cd

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 22 December 2003.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 16-24 and 37-39 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 16-24 and 37-39 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 27 June 2001 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. §§ 119 and 120

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.
- 13) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.
a) ☐ The translation of the foreign language provisional application has been received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ 6) ☐ Other:

DETAILED ACTION

This Office action is in response to applicants' Request for Continued Examination (RCE) and an accompanying amendment, both filed on 22 December 2003. Claims 1-15 and 25-36 have now been cancelled, claims 16-24 remain as previously amended, and claims 37-39 have now been added. Therefore, only claims 16-24 and 37-39 remain under consideration.

Specification

The previous objections to the disclosure of Paper No. 6 have been addressed by amendments to the specification filed on 22 December 2003. Accordingly, these previous objections are now withdrawn.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 16-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young, et al. (US Patent 6,255,022) and further in view of Schroeder, et al. (US Patent 6,379,869).

Sato teaches a process for improving etching resistance (increasing selectivity) of an organosilicon photoresist by first energy beam imaging of the photoresist with or without post-

exposure baking, developing, then second energy beam post-treatment (exposing) of the imaged photoresist (column 97, lines 42-54). Column 5, lines 6-7 show alternative use of a charged beam (electron or ion beam specified at column 3, lines 59-61) as the first energy beam and ultraviolet (UV) rays as the second energy beam. The second energy beam (UV) exposure cross-links organosilicon polymer in the imaged photoresist to form a hardened etching mask having improved resistance to subsequent etching (column 82, lines 15-18 and column 96, lines 56-64). Specific examples of organosilicon compounds useful in the photoresist are polysilane and polysilene shown by formulas [1-1] to [1-114] in columns 6-28, but particular attention is drawn to those showing Si-H and Si-CH₃ bonds, such as those in formulas [1-14] to [1-16] found in column 8 (instant claim 17 interpreted only as disclosed in the last line of instant page 11). The organosilicon photoresist containing an organosilicon compound can be selectively hardened with a charged beam by conversion into a silicon oxide/carbide-like film in order to improve etching resistance for use as an etching mask. Alternatively, the organosilicon photoresist may be used as an underlying layer that also functions as an antireflective film during exposure of an overlying top resist (column 4, lines 4-21, column 5, lines 25-67, and column 96, line 64 to column 97, line 4). The organosilicon photoresist can also contain a cross-linking agent for curing/hardening the organosilicon compound to provide increased solvent and heat resistance, as well as improving etching resistance for use as an etching mask (column 28, line 65 to column 29, line 1 and column 96, lines 56-63). Examples of cross-linking agents having multiple (double or triple) bonds are shown by formulas [3-1] to [3-88] in columns 61-72 and are described as reacting at Si-H bonds to cross-link the organosilicon polymer under the effect of heat or light at column 61, line 50 to column 62, line 51. Other examples of cross-linking agents

are described at column 82, line 1 to column 96, line 55. The overlying top resist is not particularly limited (e.g., the top resist does not have to contain an organosilicon compound (non-organosilicon resist), the top resist can be selected according to the particular end use as either a positive or a negative resist, etc., column 97, lines 5-29). Example 1 shows coating of a SiO_2 work film 11 on a silicon wafer 10, adding an underlying film having an organosilicon compound 12, and overcoating the underlying film with a resist 13 as shown in Figure 1A. The resist is baked, exposed by KrF excimer laser, baked again, then developed to form a line-and-space pattern 14 as shown in Figure 1B. An accelerating voltage of 1.8 kV was used to project an electron beam 15 on the resist pattern 14 for detecting the position of the resist pattern. A separate electron beam at a much stronger accelerating voltage of 10 kV was then used to expose and harden at least upper regions 16 at portions of the organosilicon underlying film 12 as shown in Figure 1C. Then, the resist pattern 14 and electron beam regions 16 of the underlying film are used as etching masks for dry etching of the unexposed/unhardened regions of the underlying film to form an underlying film pattern portion 17 using the resist pattern 14 as an etching mask and another underlying film pattern portion 18 using the hardened regions 16 as an etching mask as shown in Figure 1D. Both of these etching masks provided excellent anisotropic etching of the unhardened/unexposed regions of the underlying film. The unhardened organosilicon underlying film was more selectively etched than either the overlying resist pattern 14 or the electron beam hardened regions 16 of the organosilicon underlying film. The previous electron beam exposure of at least the top regions 16 of the organosilicon underlying film resulted in conversion of the organosilicon compound to oxide/carbide silicon-like film regions, which are much harder to etch than the unexposed regions of the organosilicon underlying film. It is also

noted that while comparison of Figures 1C and 1D suggests a reduction in thickness of the patterned upper resist 14 during etching, no such reduction in thickness is apparent for the electron beam hardened organosilicon regions 16. This suggests that the hardened organosilicon regions present greater resistance to subsequent etching than does the non-organosilicon resist 14 (column 99, line 25 to column 102, line 30). Example 5 shows an alternative embodiment in which the underlayer is a non-organosilicon antireflective layer 72 between the work film 71 to be etched and an overlying resist film 73, as shown in Figure 5A. In this case, electron beam exposure 75 of the overlying resist film comes first, followed by baking, developing, and helium neon laser detecting of the first resist pattern. KrF excimer laser exposure 80 of additional regions of the remaining overlying resist comes next, then further baking and developing to form patterns 76 and 81 as shown in Figures 5B-5E (column 170, line 17 to column 108, line 8). This latter example lays out a potential use for a non-organosilicon underlayer in a similar process that involves similar patterning of an overlying resist (which could be an organosilicon photoresist) before etching of an underlying layer.

Sato does not specifically require: (1) that the organosilicon photoresist be formed and patterned over the non-organosilicon resist before selective etching of an underlying layer nor (2) that the organosilicon photoresist be subsequently exposed to UV light after being imaged and developed.

Young teaches a bi-layer resist process for improving dimension control during subsequent etching of an underlying substrate (column 1, lines 8-11). A first underlayer of resist 18 (e.g., acrylic polymer (non-organosilicon), etc.) is coated on a substrate and this underlayer is baked (Figure 2, column 2, lines 53-60). The first resist underlayer 18 is covered by a second

Art Unit: 1756

resist layer 20 (e.g., silicon-containing monomer (organosilicon), etc.), which is also baked (Figure 3, column 2, lines 61-67). If the second resist 20 does not yet contain silicon as deposited, then the resist 20 would be silylated to make it resistant to subsequent dry etching (e.g., oxygen reactive ion etching (RIE), etc.). During silylation, silicon atoms would displace hydrogen-containing radicals in the resist 20 (column 3, lines 1-13). Top silicon containing resist 20 is exposed to actinic light through a patterned mask 22 (Figure 4, column 3, lines 14-16) and then developed (Figure 5, column 3, lines 17-20). Next, the non-organosilicon resist underlayer 18 is oxygen dry etched through the patterned silicon containing resist 20, which blocks the dry etchant to protect underlying portions of the resist 18 during etching (Figure 6, column 3, lines 21-24). This etching step is also called dry development and results in conversion of the remaining top resist 20 to silicon dioxide (conversion of the silicon containing top portion of the bi-layer resist to oxide, column 3, lines 46-48). This oxide conversion hardens the top silicon containing resist 20 against subsequent oxygen ashing (column 3, lines 56-64) and etching as shown in Figure 7 (column 4, lines 1-5).

Schroeder teaches a method of improving etch resistance while maintaining radiation sensitivity of a patterned (exposed and developed) resist by introducing silicon into the top and side portions of the developed resist pattern (column 1, line 60 to column 2, line 10). The resist may be either a positive or a negative resist and imaging of the resist is by actinic radiation (e.g., UV radiation, x-ray, electron beam, etc., column 2, lines 37-43). After patterning by imaging and developing, the resist is deprotected by deep UV flood exposure to expose active sites of the resist base resin to prepare it for subsequent reaction with an etch protectant, followed by baking or heating (column 4, lines 6-11). Next, the developed and deprotected resist is treated with an

etching protectant, which includes a silylating agent for bonding to the resist base resin. The silylating agent provides increased etching resistance by contributing silicon to the resist structure (column 4, lines 28-42). Silylated top and side surface regions 4 are shown on the developed resist pattern 3 in Figure 3. These silicon containing surface regions 4 possess greater etching resistance than do unmodified non-silicon containing regions (column 4, lines 43-46). These silicon containing top regions are particularly advantageous for imparting etching resistance against oxygen plasma during subsequent etching through the resist. The etching rate of these silicon containing top regions is less than 45% of that for the non-silicon containing resist portions. This allows a silicon containing resist having hardened top portions to be formed into thinner layers to produce sharper images (column 4, line 63 to column 5, line 4).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to have reversed the order of the non-organosilicon resist and the organosilicon photoresist as taught by Sato so that the underlying layer was the non-organosilicon resist and the top layer was the organosilicon photoresist as taught by Young. This is because both resist layers are patterned by radiation (e.g., UV, electron beam, etc.) imaging and the overall etching resistance of a bi-layer resist etching mask for improved selectivity is a combination of the etching resistance of both layers when added together, regardless of order. However, the silicon containing resist, as the stronger etching mask, should logically be the first line of defense as the top resist layer over an underlying non-silicon containing resist, as the weaker etching mask, in protecting the non-etched areas of the underlying substrate or work film from overetching. Both Young and Schroeder choose this configuration. It would also have been obvious to subsequently expose the developed top portion of the silicon containing resist as taught by

Art Unit: 1756

Schroeder to convert it into a hardened layer for improving etching resistance. Sato, Young, and Schroeder all relate to the same art of hardening a silicon containing resist for improving etching selectivity and resistance of the resist during subsequent etching.

Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato in view of Young, further in view of Schroeder, and further in view of Tsai, et al. (US Patent 5,899,748).

While showing UV exposure of a developed organosilicon photoresist image to cross-link and harden the photoresist layer followed by subsequent etching through the hardened photoresist layer, Sato, Young, and Schroeder do not specify that the UV exposure should be conducted in an etching chamber.

Tsai specifies UV exposure of a photoresist layer in an etching chamber that provides UV emission and implies the advantage of simplified processing over UV exposure and etching in separate chambers (which would require taking the photoresist layer off-line for UV treatment before returning the photoresist layer to the etching chamber described at column 6, lines 30-39).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to expose the photoresist to UV hardening as taught by Sato, Young, and Schroeder in an etching chamber that provides UV emission prior to etching with the expectation of simplifying processing (by avoiding taking the photoresist to a separate UV chamber before returning the photoresist to the etching chamber) as taught by Tsai.

Claims 19-23, and 37-39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato in view of Young, further in view of Schroeder, further in view of Tsai, further in view of

Art Unit: 1756

Kishimura (US Patent 5,123,998), further in view of Singh, et al. (US Patent 6,479,820), and further in view of George, et al. (US Patent 4,980,563).

Sato, Young, Schroeder, and Tsai do not specify use of argon (Ar) inert gas flowing to the etching chamber at about 1000 to 3000 sccm during UV exposure generated by neon (Ne) gas and do not specify that the flow rate of Ne must be about 0.2% to 0.8% of the flow rate of Ar. Also, Sato, Young, Schroeder, and Tsai do not require striking plasma composed of Ar and Ne gases to generate UV in the etching chamber.

Kishimura teaches UV imaging (exposing) of a photoresist in inert gas (e.g., Ne, Ar, He, N₂, etc., column 10, lines 5-9) for more efficient cross-linking of the photoresist by UV exposure (column 5, lines 58-68), selective silylation to incorporate silicon (Si) into the photoresist by forming Si-CH₃ bonds (shown in Figure 2B) with the unexposed areas of the photoresist (column 6, lines 21-25), followed by developing and dry etching by O₂ reactive ion etching (RIE) to convert the silylated regions of the photoresist to SiO₂ as a powerful shielding material to O₂ plasma, allowing only the exposed regions to be removed by etching (column 6, lines 26-31).

Singh describes plasma post-treatment of a developed photoresist image in which the plasma includes one or more inert gases (e.g., Ar, Ne, He, Ne, Kr, Xe, etc.) flowing at 10 sccm to 10 slm (10,000 sccm) under a pressure of 0.0001 to 1,000 Torr to ionize and maintain the inert gas in a plasma state at column 6, lines 7-23. Any suitable temperature can be used for generating ions in the plasma (e.g., about 25 °C to about 1400 °C, etc., column 6, lines 25-30).

George shows a UV lithography process and apparatus using a UV source gas (e.g., Ne for 85 nm, He for 65 nm, Ar for 130 nm, krypton (Kr) for 150 nm, xenon (Xe) for 170 nm, etc.) at column 3, lines 22-32. Ar, Kr, Xe, or other suitable gas or mixture is placed on a cold plate or

Art Unit: 1756

heat exchanger. The cold plate is cryogenically cooled (e.g., maintained at a temperature of about 77 °K by liquid nitrogen or about 20 °K by gaseous helium refrigeration, etc.). UV radiation is produced with high conversion efficiency to UV of about 50 Percent (column 3, lines 33-50).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the UV hardening exposure of a developed photoresist in an etching chamber that provides UV emission and etching using the hardened photoresist in the same chamber as taught by Sato, Young, Schroeder, and Tsai with Ar inert gas flow to the etching chamber during UV hardening at a flow rate of 10 to 10,000 sccm as taught by Singh (encompassing the Ar inert gas flow rate of about 1,000 to 3,000 sccm in instant claims 19-20) for more efficient cross-linking of the photoresist by the UV exposure as shown by Kishimura. It would also have been obvious to control inert gas pressure at 0.0001 to 1,000 Torr for any suitable temperature (e.g., about 25 °C to about 1400 °C, etc., which approaches and reads on the 0 °C of instant claim 38, especially given the wide range of suitable pressures and temperatures) in the etching chamber during plasma post-treatment (UV exposure) of the developed photoresist image as shown by Singh to strike and maintain the inert gas plasma in the etching chamber as described by Singh (instant claim 37). During UV generation from a suitable source gas or mixture thereof, colder temperatures than the exemplary range shown by Singh, extending even down to 20 ° K or 77 °K (-253 °C or -196 °C, respectively) would have been expected to produce the UV at a high conversion efficiency, as shown by George (encompassing the 0 °C of instant claim 38).

Art Unit: 1756

It would also have been obvious to one of ordinary skill in the art at the time the invention was made to combine the UV exposure hardening of developed photoresist and etching taught by Sato, Young, Schroeder, and Tsai with a UV generation source having (1) Ne gas (instant claims 21 and 39) to obtain an 85 nm emission or (2) a mixture of Ne and Ar (such as that obtained by a flow rate of Ne between about 0.2% and 0.8% of the flow rate of Ar, instant claim 22) to obtain an emission between 85 nm and 130 nm (UV light) as shown by George.

Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato in view of Young, further in view of Schroeder, and further in view of Rangarajan, et al. (US Patent 6,451,512).

While clearly showing conversion of at least the top portions of regions of an organosilicon photoresist, Sato, Young, and Schroeder do not specify that these top portions be limited to 5% to 75% conversion of the developed organosilicon photoresist to a hardened layer before etching using the hardened layer.

Rangarajan teaches post-developing photoresist silylation in UV to enhance incorporation of silicon (Si) and cross-linking of the resulting organosilicon polymer in the photoresist for increased etching resistance (selectivity) at column 3, lines 14-26, column 4, line 66 to column 5, line 4, column 5, lines 14-42, 58-62, and column 7, lines 51-55. Column 6, lines 58-61 shows use of an inert gas (e.g., Ne, Ar, He, etc.) during the UV treatment. Si atoms are incorporated into the photoresist during UV hardening to a depth of between 2% and 100% of the photoresist thickness (column 10, lines 47-52).

Art Unit: 1756

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the UV hardening of Sato as discussed above in order to harden the top 2% to 100% of the developed organosilicon photoresist layer (encompassing the 5% to 75% hardening of instant claim 24) to improve the etching resistance (selectivity) of the organosilicon photoresist layer as shown by Rangarajan.

Response to Arguments

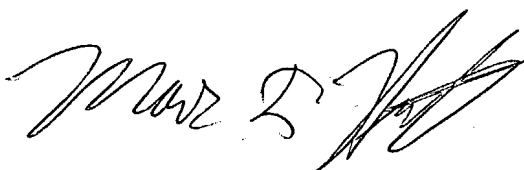
Applicants' arguments filed 22 December 2003 with respect to previously amended claims 16-24 and newly added claims 37-39 have been considered but are moot in view of the revised ground(s) of rejection set forth above.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Ruggles whose telephone number is 571-272-1390. The examiner can normally be reached on Monday-Thursday and alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Huff can be reached on 571-272-1385. The fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.



John Ruggles
Examiner
Art Unit 1756

RECEIVED
SUPERVISOR
TELEPHONE UNIT 1756